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James F. Gilligan
Assistant US Attorney
U.S. Attorney's Office Western District of Texas
601 N.W. Loop 410; Suite 600
San Antonio, Texas 78216

Re: Morgan Harris DOB 12/19/1997,
Kyle Workman and Morgan Harris vs. USA, consolidated in
Civil Action 5-18-CV-00555-XR (Holcombe et al vs. USA)

Dear Mr. Gilligan:

As per your request, I am pleased to submit this independent assessment of whether Ms. Morgan Harris has sustained, or is at future risk of, adverse health effects caused by inorganic lead released from retained bullet fragments. In preparing this report, I reviewed the medical records and the case documents listed in the Appendix, as well as toxicological and medical literature. I understand that new discovery and independent medical examinations may be forthcoming, and I reserve the right to update my assessment should additional relevant information become available. My qualifications, set forth in my Curriculum Vitae, and my billing rates are provided separately with this report.

Based on the available records, aspects of Ms. Harris' medical history pertinent to my toxicological assessment may be summarized as follows:

At approximately 11:40 on November 5, 2017 Ms. Morgan Harris, age 19, was in the sound booth of the First Baptist Church in Sutherland Springs, Texas. A gunman wielding an AR-556 semi-automatic rifle loaded with unspecified ammunition suddenly entered the church and fired at numerous church occupants. Ms. Harris was struck in several locations, primarily the left lower extremity, by bullet fragments and shrapnel that penetrated the sound booth. Following the shooting she was ambulatory with stable vital signs, and at 12:51 she was transported by ambulance to Connally Memorial Hospital in Floresville, TX. Her left lower extremity wounds were found to be hemostatic and without exit points, and she had good pedal pulses. She was transported to University Hospital in San Antonio at approximately 14:00 for further evaluation

and disposition. Radiological assessment at Connally Memorial on November 5, 2017 included plain films of the tibia and fibula revealing retained metallic shrapnel in soft tissues around the knee and calf. Later that day at University Hospital a CT angiogram of the left lower extremity was negative for vascular injury but noted "two punctate metallic foreign bodies are seen within the left medial tibial plateau without discrete displaced fracture or plateau impaction/collapse. Innumerable metallic foreign bodies are seen along the medial lower left thigh, left knee, and proximal lower leg soft tissue with associated overlying soft tissue laceration, subcutaneous emphysema, and hematoma." A chest x-ray was negative for acute cardiopulmonary disease but noted, "Punctate metallic ballistic fragments overlies the right shoulder without underlying osseous abnormality." A chest CT scan obtained on December 13, 2017 revealed "Metallic density shrapnel again visualized in the soft tissues of the right shoulder and adjacent to the right clavicle."

A chart note by the trauma service at University Hospital on November 5, 2017 stated in part, "She denies any pain other than in her left lower extremity." The physical examination included "Four erythematous lesions to the anterior chest, non-tender," "ecchymosis under the right eye", and "3 wounds to the left lower leg." The past medical history stated, "nerve pain secondary to chronic neck" but no imaging of the head or neck were obtained on that date. Ms. Harris was discharged from the University Hospital ED on November 5, 2017 with instructions for wound care and outpatient follow-up. Outpatient trauma clinic follow-up notes through January 4, 2018 indicated that the wounds "have healed well." According to chart notes of Linda Shriner MD (see below), following her discharge from University Hospital Ms. Harris ambulated on crutches for three weeks, followed by a single point cane for two weeks. She returned to work as a front office assistant for a chiropractic office in January 2018.

Ms. Harris appeared for an annual physical examination at Crossover Magenta Health Clinic on May 29, 2018. In a chart note, family physician Michelle Rodriguez, MD wrote, "Patient states had gun shot wound in November but complained of "footdrop [that] began in late February [2018] primarily in left and not sure why now, partially on right." Dr. Rodriguez noted that Ms. Harris also had, "History of compressed nerve in neck few years ago and would get numbness on right side of body, mostly in right lateral leg and left shin to the point she can't feel the razor when shaving." She reported a history of chiropractic adjustments of her low back, more frequent since the shooting in November 2017. With respect to retained bullet fragments or shrapnel, Dr. Rodriguez wrote, "Most of pieces in hands and face have come out on their own." A negative work-up for Juvenile Arthritis at age 15 was listed without further elaboration. The review of systems was negative; no complaints of cognitive deficits or memory loss were recorded. Physical examination noted, "L>R weak dorsiflexion. 4/5 proximal bilateral lower extremities.... R>L reduced patellar reflexes." The plan was to review imaging studies and to refer to "in-house chiro to determine what testing will be next step."

Selena Gray, D.C. of Crossover Magenta Health saw Ms. Harris for consultation on June 11, 2018. The consult note stated, "... Footdrop began initially on left in February and patient is now noticing right foot drop is worse. Patient states that she can't wriggle toes on left. Patient notes this is progressively getting worse. She states that she was off crutches in December. Initially, she

had severe back pain. Shrapnel in multiple places so cannot get MRI. Four mechanical falls since New Year.... Positive history of severe neck pain and abrupt onset headaches: chiro light therapy and manipulation, did not improve with 3 weeks of physical therapy. Never had MRI or CT of neck. Only x-rays were taken. She had abrupt onset of headaches that became progressively worse over past 2 years. Patient states that she had concussion at work (did not lose consciousness but mild memory loss), MVA 3 days later, minor fender bender and was wearing seat belt at < 30 mile/hour, went to 6 Flags and rode Batman ride-could not turn head with spasm. She notes that she is unable to ride roller coaster for the past 5 years due to neck/headaches. Currently, she is under active care of chiropractor Dr. Joseph Michael who practices Logan technique and uses both activator and hands.... Currently, she requires assistance with walking stick for both ambulation and balance.... She notes cramping in legs and intermittent numbness in lower legs." Physical examination revealed "severe steppage gait bilaterally." Romberg test was positive. Patella reflex was 2/5 on left and absent on right. Achilles reflex was sluggish bilaterally. Ankle dorsiflexion and big toe flexion could not be performed bilaterally.... Sensation to light touch appeared intact in bilateral lower thigh. Patient reports diminished sensation to light touch along right lateral, anterior and medial lower leg and sole of right foot relative to left lower leg. Patient notes greater diminished sensation along medial side and bottom of foot." "Assessment: Progressive neurological deficits since February 2018---diffuse sensory/motor loss in bilateral lower extremity. Absent right patellar reflex. diminished bilateral Achilles DTR, +steppage gait."

Dr. Rodriguez subsequently referred Ms. Harris for neurological consultation with Suzanne Gazda, MD at the Neurology Institute of San Antonio. In a consult note dated June 21, 2018, Dr. Gazda indicated that initially following the November 5, 2017 shooting and gunshot wounds Ms. Harris "continued to be very active... She was teaching Martial Arts up until November of 2017. Sometime around December she started to notice weakness in the lower extremities. She had subsequently developed over the last few months a bilateral foot drop. She tells me in January when she began to notice this she thought her legs were weak from not working out like she had been up until November. Her ongoing symptoms are:

- 1). Severe low back pain, radiating into her hips. This comes and goes.
- 2). Bilateral foot drop and generalized weakness in both legs.
- 3). Knee pain.
- 4). Gait imbalance related to foot drop. It appears from her history that the foot drop began on the left and then she developed a right foot drop.
- 5). About two years ago she started to have right sided numbness. She thought this was related to a pinched nerve in her neck, but it was total right sided numbness, not isolated in the arm."

Review of systems was remarkable for "swollen feet, anxiety, back/neck pain, arm/leg pain, joint pain/swelling, muscle weakness, numbness/tingling, and tremors/hand shaking" The past medical history was also remarkable for headaches. No complaints of cognitive deficits were noted.

Neurological examination revealed a normal mental status: “The patient is alert and cooperative with fluent speech. There is no aphasia, agnosia, or apraxia.... Intelligence is normal for age and educational level....Concentration span and memory skills are intact for both visual and verbal tasks.” Aside from bilateral foot drop, there was normal strength and tone in all extremities, and normal sensation in all extremities. Cerebellar examination and Romberg were negative. The plan was to explore further neuroimaging, obtain laboratory tests, and visual evoked potentials. Bilateral ankle foot orthotics were prescribed for foot drop. Laboratory test panel on June included a C677T mutation in Methylenetetrahydrofolate reductase (MTHFR), a blood lead concentration of 8 µg/dL (laboratory reference range 0 – 19 µg/dL), hemoglobin 13.3 (ref. range 11.1 – 15.9), BUN 13, creatinine 0.61. Please see table for additional lead test results obtained on Ms. Harris.

TABLE. Lead (inorganic) Test Results – Morgan Harris

Date	Matrix	Result	Laboratory	Ordering MD
06/21/2018	Blood	8 µg/dL	LabCorp	Gazda
10/15/2018	Blood	7 µg/dL	LabCorp	Gazda
10/15/2018	Blood	5.86 µg/dL	Quicksilver Scientific	Gazda
10/23/2018	Blood	6 µg/dL	LabCorp	Gazda
10/23/2018	Urine – 24 hour	3 µg/24 hr	LabCorp	Gazda
03/05/2019	Blood	3 µg/dL	LabCorp	Shriner
04/09/2019	Blood	2 µg/dL	*	Shriner
06/06/2019	Blood	3 µg/dL	LabCorp	Shriner
06/06/2019	Urine – 24 hour	None Detected**	LabCorp	Shriner
07/05/2019	Blood	2 µg/dL	LabCorp	Shriner
07/05/2019	Urine - spot	2 µg/L	LabCorp	Shriner
07/29/2019	Blood	2 µg/dL	LabCorp	Shriner
07/29/2019	Urine – Spot	1 µg/dL	LabCorp	Shriner
10/17/2019	Urine- Spot	None Detected	LabCorp	Shriner
10/17/2019	Blood	3 µg/dL	LabCorp	Shriner
10/21/2019	Urine – 24 hour	None Detected	LabCorp	Shriner

* mentioned in clinic note but laboratory report form not in chart records supplied

** Limit of detection = 1 µg/L

On July 3, 2018, a CT of the head with and without contrast interpreted by radiologist James E. Dix, MD, found “profound dilation of the lateral, third, and fourth ventricles...Large upper cervical cord syrinx is demonstrated on the small portion of the upper included cervical spine. Impression: Marked hydrocephalus and large upper cervical cord syrinx is detected. MRI with CSF flow through the foramen magnum would be useful in evaluating for obstruction.”

On July 10, 2018, visual evoked potential findings conducted by Dr. Gazda were within normal limits. On July 10, 2018, an NCV/EMG study of the lower extremities was performed and

evaluated by R. Braden Neiman, MD of the Neurology Institute of San Antonio. The patient presented with “primary complaint of bilateral weakness and numbness to the feet.” There was *normal nerve conduction velocity and amplitude in the peroneal and tibial motor nerves bilaterally, and the plantar, peroneal and sural sensory nerves bilaterally*. The report stated, “Impression: There is electrodiagnostic evidence of prolonged unresponsive F waves and H waves bilaterally. *The peripheral neuropathic wave forms look intact*. Differential diagnosis could be an early demyelinating neuropathy, more proximal nerve root lesion, or central process. Clinical correlation is recommended” [Emphasis added.] EMG was remarkable for no response at the right and left anterior tibialis.

On July 11, 2018, Ms. Harris had a follow-up neurological evaluation with Dr. Gazda. Dr. Gazda’s assessment was “Autoimmune neuropathy: ... On her visit July 11, 2018, all of her neuropathy lab data is negative, I suspect this is autoimmune induced. Surprisingly there is marked hydrocephalus on her CT scan, suggestive of an Arnold Chiari malformation.” A trial of IVIG [intravenous immunoglobulin] was considered, but first a neurosurgical consultation was recommended.

On July 11, 2018, Ms. Harris was seen in consultation by neurosurgeon Arnold Vardiman, MD of Neurosurgical Associates of San Antonio. Dr. Vardiman noted the patient’s history of gunshot wounds, bilateral foot drop and sensory changes in the lower extremities, and the abnormal head CT “demonstrating profound ventriculomegaly with evidence of hydrosyringomyelia extending into the upper cervical canal.” Physical examination noted, “Her motor examination reveals bilateral foot drop. Sensory examination is consistent with peripheral sensory neuropathy.” The plan was to obtain a cervical CT scan and to investigate the possibility of obtaining an MRI. Dr. Vardiman saw Ms. Harris in follow-up on August 29, 2018. He noted that the CT of her cervical spine demonstrated, “profound hydrosyringomyelia with apparent associated Chiari malformation.” Neurological review of systems was negative for memory loss, problems with memory, speech, or concentration. The diagnosis was “Arnold-Chiari syndrome without spina bifida or hydrocephalus....There is certainly a variety of complicating factors, but *I am very concerned that Morgan, in fact, has a symptomatic Chiari malformation and associated hydrosyringomyelia*.” [Emphasis added]. Dr. Vardiman recommended that his colleague, neurosurgeon Christopher Bogaev, offer a second opinion.

In a consultation dated September 4, 2018, Dr. Bogaev wrote, “She is not able to have an MRI scan because of the bullet fragments remaining in her body. She did not receive any bullet wound to the spine, just the lower extremity. She has miscellaneous superficial shrapnel wounds elsewhere. CT of the brain and lumbar spine showed a large cervicothoracic syrinx with syringobulbia. She also has diffuse hydrocephalus involving the entire ventricular system.” Dr. Bogaev’s history noted Ms. Harris “began developing more ataxia in February 2018.” Review of systems was positive for balance disturbance, excessive fatigue, and problems with memory. On physical examination, “She has 4/5 strength throughout her lower extremities except for 3/5 dorsiflexion and plantar flexion in the right lower extremity. The patient has diffusely diminished [sensation] throughout the bilateral lower extremities. Reflexes are hyperactive in the lower extremities. She is unable to ambulate without a cane.” The Assessment stated, “*Ms. Harris has*

had worsening neurologic dysfunction from diffuse hydrocephalus as well as syringomyelia." [emphasis added]. He recommended neurosurgical placement of a ventriculoperitoneal shunt as an initial management step.

Ms. Harris initiated physical therapy with Marc Gardner PT at Crossover Magenta Health on July 26, 2018. His initial note indicated that Ms. Harris' chief concerns were "Fatigue with walking, low back pain, and frequent falls...Weakness is worse in the right leg compared to the left." Physical examination noted, "marked atrophy of the tibialis anterior and peroneals of the right > left lower extremity." A physical therapy note by Marc Gardner PT dated August 14, 2018 noted, "She resigned from her job at the chiropractic office because of emotional stress involving clients etc. at the office. Went and got adjusted throughout her spine this AM. She feels the decrease in stress has already helped to relieve her pain." On August 21, 2018 Mr. Gardner noted that Ms. Harris "Reports some of her overall fatigue may be due to low adrenal gland function that was confirmed prior to neurologic decline." On September 4, 2018 he recorded, "She feels her symptoms have plateaued (latest decline in function was 2/2018 to 6/2018)." On September 14, 2018 Mr. Gardner wrote, "Source of lower extremity weakness has been diagnosed as pressure due to hydrocephalus." His note on September 21, 2018 recorded that Ms. Harris, "had increased back pain with jiu jitsu class following last visit." On September 25, 2018 he recorded that Ms. Harris "feels numbness on the right side of her abdomen today." October 5, 2018 recorded that Ms. Harris intermittently complained of a "strong pins and needles feeling in the right lower leg." On October 26, 2018 he assessed, "Very gradual improvement in functional strength noted with sit to stand test AND increased resistance with use of bike."

Ms. Harris returned to Dr. Gazda for follow-up neurology consultation on September 12, 2018. Dr. Gazda noted the diagnosis and recommendation of the neurosurgeons but did not otherwise comment on their findings. Her recommended treatment consisted of IVIG (intravenous immunoglobulin). She wrote, "I believe the shrapnel in her body related to the gunshots she acquired with the mass shooting in Sutherland Springs could have precipitated metal toxicity in her body resulting in an autoimmune phenomena." She also recommended a blood metal test panel be sent to Quick Silver laboratory. At the next follow-up visit on October 9, 2018, it was noted that a lumbar puncture was required for the IVIG treatment to be approved, (presumably by insurance), as well as a thyroid and lower extremity ultrasound to rule out a deep venous thrombosis. A fluoroscopically-guided lumbar puncture (spinal tap) conducted on October 9, 2018 by Dr. John Clement was remarkable for an elevated opening pressure of 33 cmH₂O; CSF cytology and chemistry were negative. At the time of follow-up on October 16, 2018, Dr. Gazda wrote, "She feels that overall her bilateral foot drop is relatively stable, but it has definitely progressed over the last six to eight months [sic]. She also has distal paresthesias, but no severe neuropathic pain. Her upper extremities are not involved. There is no bowel or bladder incontinence, she also suffers from a very minimal tremor." A lumbar puncture performed on October 9, 2018 revealed normal cytology and chemistry. The opening pressure was not reported in the notes provided, but a physical therapy note by Mark Gardner PT dated October 23, 2018¹ indicated that Dr. Gazda told him that the opening pressure was "elevated...as expected with

¹ Bates number: MHARRIS-19-705-000165

hydrocephalus.” Dr. Gazda’s plan included “Continue working for IVIG for demyelinating polyneuropathy” and to have patient follow-up with the neurosurgeons.

On November 7, 2018, Dr. Gazda saw Ms. Harris for follow-up neurology consultation. She wrote, “I reviewed the results of her Quick Silver Scientific; her lead level is very, very high [sic].Quick Silver: lead is at the 99.9 percentile.” Although not mentioned explicitly in Dr. Gazda’s chart note, the Quick Silver laboratory blood lead concentration reported for blood collected on October 15, 2018 was 5.86 µg/dL (laboratory reference range < 2.10. Percentile 99.9 %).² In her Assessment, Dr. Gazda wrote, “1. Autoimmune Neuropathy:...I believe this is a lead induced demyelinating neuropathy related to retained shrapnel from her injury last November 2018 when she unfortunately [was] at the massacre that occurred at a church in Southerland Springs

2). Hydrocephalus and syringomyelia: The patient has seen Dr. Vardiman and Dr. Bogaev; they are recommending surgery. Dr. Bogaev did not feel a Chiari decompression would be the best surgery. They have elected to recommend a VP shunt.

3). Shrapnel injury when she was involved in a mass shooting at a church 11/06/17. She has significant shrapnel injury, bullet fragments remaining in her body.

Treatment: 1. Numbness. *I am recommending chelation therapy.* [emphasis added]. At the next follow-up visit, Dr. Gazda indicated that Ms. Harris had been referred to Dr. Sandra Shriner for heavy metal intoxication. The insurance company had denied coverage for IVIG treatment. Dr. Gazda stated, “She has an autoimmune neuropathy most likely related to heavy metal intoxication [sic], but whatever the cause is this is an inflammatory polyneuropathy that is autoimmune induced, consistent with the diagnosis of CIDP.... She is working with Michelle Ackerman on the Wahl’s protocol.”³

Dr. Gazda referred Ms. Harris to Dr. Neiman for a repeat NCV/EMG study that was performed on January 8, 2019. The findings again included normal sensory and motor NCV and amplitude in the distal lower extremities. The available records contain no comment by Dr. Gazda regarding the results.

On November 27, 2018, Ms. Harris was evaluated by Sandra Shriner, MD at Aidia Individualized Care, a self-described “integrative pain medicine practice.” The chief complaint was “heavy metal detox.” The past medical history noted, “history of neck pain, history of headaches, drop foot, lead poisoning via shooting, concussion ‘punched in the head’ and whiplash injury due to sparing, no level [sic] of consciousness but memory loss for 1.5 hours (grade II).” Dr. Shriner’s account of the patient’s medical course noted that in February 2018 she began tripping and falling with a worsening gait pattern.” Dr. Shriner also noted that “She denies nightmares but thinks about the tragedy every day.” She was reported to be receiving physical therapy twice a week, and to be consuming ibuprofen (or sometimes Tylenol) 2 grams daily for the past 8 to 12 months. Review of systems was remarkable for disturbed sleep – waking up 4-5 times a night and tossing and

² The Quick Silver laboratory reported noted, “The blood lead reference level for children ages 1-5 is 5 µg/dL, which represents the 97.5 percentile. - CDC update October 30, 2012”

³ Wahl’s protocol is an investigational protocol, featuring a Paleo diet, stress reduction, and other lifestyle techniques that is advocated by Terry Wahls, MD for treatment of multiple sclerosis and chronic autoimmune diseases (<https://terrywahls.com>).

turning due to hip and neck pain. The patient reported headaches. Cognitive status was described as “No impairments.” Physical examination was remarkable for bilateral muscle atrophy of the distal lower extremities. Sensory examination was not documented. Mental status was reported as “Normal... Recent and remote memory is intact. Attention span, concentration, language, and fund of knowledge sufficient. Speech is clear in tone, volume, and rate.” In a section of the consultation entitled visit summary, Dr. Shriner wrote:

“In summary, her clinical history and examination point to a lead-induced sensory motor neuropathy and the cervical syrinx appears to be asymptomatic other than neck pain with her exam showing no evidence of myelopathy or central cord syndrome. Although, she is in a precarious situation with the normal pressure hydrocephalus and syringomyelia without any form of decompression.

While the CDC has normative data on acute lead toxicity, there is no standard method for determining the chronic burden load. Although her lab values reflect a toxic dose for children, there is a strong temporal association and clinical findings consistent with a lower motor neuropathy. Her severe clinical presentation with lower lead levels, although any lead level is toxic, makes one question her normal innate ability to process and eliminate toxins or diminish her total body burden. I will get genetic testing to rule out deficits in phase I and phase II detoxification process. Her nutritional status is fair to poor, and currently, her system would not tolerate oral chelation therapy... Supplementations to be given to correct macro and micronutrients deficiencies, enhance the healing process, and support the nervous system so she may safely tolerate gentle oral chelation therapy.”

Dr. Shriner’s diagnoses included “Right and Left Foot Drop;” Toxic Effects of Lead; Post-Traumatic Stress Disorder, Chronic; and idiopathic normal pressure hydrocephalus. There was no mention in Dr. Shriner’s note of the findings of Ms. Harris’ lower extremity NCV/EMG obtained in July 2018.

The available narrative notes did not contain details regarding any lead chelation regimen that may have been prescribed at the time of the November 28, visit, but do contain a copy of a prescription dated January 8, 2019 for “DMSA (succimer) 250 mg, 1 tablet at bedtime every 3 days. #15.” [However, as noted below, a chart entry dated July 10, 2019 indicated that Ms. Harris was a chelation regimen of DMSA (succimer) 250 mg, Sunday, Wednesday, and Saturday, from beginning in February 2019 that was reduced to Sunday, Wednesday and Saturday every other week beginning in April 2019 through July 2019.]

In a follow-up chart note dated March 5, 2019, Dr. Shriner indicated “Morgan is doing quite well, she regained some motion in both feet.” She was noted to have nocturnal awakening 2 to 3 times due to discomfort in both hips that was a “long-standing problem prior to the shooting.” A note dated March 25, 2019 indicated that Ms. Harris had been seen in an urgent care center on March 21, 2019 complaining of chest pain and was prescribed a proton pump inhibitor. On physical examination she was noted to be ambulating with bilateral ankle-foot orthoses and a steppage

gait. Motor examination was normal in upper extremities and “in general left lower extremity is better than the right.” Assessment noted in part

“Lead neuropathy was severe bilateral foot drop. She continues to improve with increased strength since her last visit. Laboratory values are all within normal limits.” She was advised to continue succimer every other week (250 mg every other Sunday, Wednesday and Saturday). This regimen was continued at the time of a follow-up visit on April 9, 2019. On that date Dr. Shriner wrote, “21-year-old female who was a gunshot victim and due to impaired detoxification pathways she suffered severe distal motor and sensory polyneuropathy with bilateral foot drop at a lead level of 10. Her current lead level is 2 and for the last 8 weeks she has had motor recovery and increased sensation. I would like to continue the chelation alternating every other week.”

Dr. Shriner observed incremental improvement in Ms. Harris’ distal lower extremity strength on May 8, 2019. She noted that Ms. Harris had resumed a kickboxing class barefoot. Continuation of the succimer regimen was advised. On June 20, 2019, physical examination revealed left ankle dorsiflexion 2+/5, right dorsiflexion 1/5....Sensation: improved with new tactile sensation and tingling bilaterally.” Assessment included, “Morgan continues to make improvements from a motor and sensory perspective left distal extremity better than the right. Improve limb girdle strength with improvement in gait. Her lead level remains at 3 with negative urinary lead. Concerns are for being able to bind and extract the remaining lead.” The chelation regimen was continued. On July 10, 2019, an ultrasound scan of the left lower extremity did not reveal any intraarticular bullet fragments. The recent blood lead concentration of 2 µg/dL was noted. Dr. Shriner recommended high dose dietary fiber to bind lead but to “stop the succimer for drug holiday... Unfortunately, I think we have extracted as much as we can from the soft tissue and there is no large pieces to be extracted from the bone or joints and with time lead will slowly dissipate into the soft tissues from the bone. At those times recommendation are for short higher dose chelation intermittently to extract the soft tissue lead. She will continue to be monitored closely by serum and urine as to correlate the exact timing of this intermittent high dose chelation.”

Ms. Harris consulted her primary care provider Dr. Rodriguez at Magenta Health for a “wellness examination” on August 30, 2019. A PHQ-9 screening test yielded a score consistent with “mild depression.” The history noted, “Sleeps 9 – 10 hours. Wakes fatigued. Will wake in middle of night since childhood but worse with body pain.” The patient was using AFO devices on both distal lower extremities to assist with ambulation. The diagnostic assessments included “Daytime sleepiness – R40.0”.

Dr. Shriner conducted a follow-up evaluation on October 25, 2019. Ms. Harris complained of “paresthesias along the right lateral thorax which feels like a tingling sensation. She reports this has been there before but not articulating it other than complaining of a muscle strain.” On neurological evaluation, Dr. Shriner noted, “more tingling sensation noted on the right from C5 through most of her thoracic spine....She does not appear to have a neurological level and there are no signs of upper motor neuron dysfunction....Unclear as to why she has impaired sensation in this region based on her clinical exam today.” Dr. Shriner also recorded that, “She is complaining of short-term memory loss and impairment in organizational skills. She indicates

that she has forgotten two appointments. However, she denies feeling depressed when questioned by her mother. She is seeing a psychologist and she will send me his contact information.” In the Assessment, Dr. Shriner wrote, “*Today is the first time she reports cognitive impairments involving short-term memory and organizational skills* [emphasis added]. She is to share her contact information with me so I may reach out to the psychologist that she recently started seeing. Recommendations would be for complete neurocognitive testing to objectively document her symptoms.”⁴ On November 1, 2019, Dr. Shriner noted that Ms. Harris continued to complain of tingling in the right lateral thorax. On neurological examination “Sensory assessment today shows decreased sensation on the right side starting at T11.” Ankle dorsiflexion was 4+/5 on left and 3+/5 on the right. Dr. Shriner noted, “Although improved, she has significant motor dysfunction and would greatly benefit from the continual stimulation by Bioness devices.” Dr. Shriner noted, “She is doing well at work and was recently evaluated in the top 5% [of company] and they are making all modifications needed for her employment. Currently she does all job tasks without restrictions.”

There was no indication in the records available for review that Ms. Harris received further evaluation or treatment from Drs. Shriner, Gazda, Vardiman, Borgaev, or Rodriguez after November 2019.

Ms. Harris saw a counselor named Manuel T (Terry) Davis, Jr. at the Ecumenical Center (Center for Hope and Healing) in La Vernia, TX beginning in August 2019. Brief notes indicate that she received counseling for anxiety. The last note available for review dated October 17, 2019 indicated, “elevated diagnosis to PTSD, due to continued anxiety and panic.”

Christopher Ticknor, MD, issued a medicolegal psychiatry report on Ms. Harris dated December 19, 2019 that was apparently based on a patient interview conducted on December 15, 2019 and a record review. Dr. Ticknor’s assessment was that Ms. Workman “suffers from moderate to severe adjustment disorder with depressed mood symptoms.” Dr. Ticknor’s did not attribute this psychiatric condition to lead toxicity, nor did he clearly diagnose the presence of lead-related neurocognitive impairment. Dr. Ticknor’s report did not cite any blood lead measurements that had been measured in Ms. Harris. Nonetheless, he indicated that patients such as Ms. Harris who have retained lead bullet fragments “develop high levels of lead toxicity that despite best efforts to chelate and reduce the lead, never achieve a non-toxic level. For a 22-year-old woman like Morgan Workman, this means that if she were to conceive a child, exposure to lead toxicity in utero would ultimately lead to brain damage and permanent disability in the child.”

Alex Willingham MD of South Texas Physical Medicine and Rehabilitation completed a New Patient Evaluation on January 16, 2020. The gunshot injuries sustained in 2017 were noted, otherwise “no significant past medical history noted.” Dr. Willingham wrote, “She saw Dr. Suzy Klaus Gazda approximately 1 1/2 years ago with the development of the foot drop, bilateral, left and then right. A hydrocephalus was also found. She saw Dr. Vardiman and Dr. Bogaev who

⁴ Records from any psychologist Ms. Harris had consulted in October 2019 were not provided for review, nor were the results of any neurocognitive testing that may have been conducted.

discussed VP shunt; however, ultimate etiology of her foot drop was determined to be lead poisoning but the initial blood level was not high. The large ventricles were felt to be congenital and the final discussion was that no shunt was needed. However, subsequently, with hair, blood and urine and heavy-metal screens that led to genetic study identifying a metabolic filtering abnormality." "She complains of memory lapses or loss, fatigue, numbness, unsteady gait, lower back pain, anxiety.... On physical examination, tibialis anterior strength was 4/5 bilaterally. Sensation was "decreased on the left from the foot to the thigh....She claims there is some decreased sensation on the right up to the trunk," however no sensory abnormality in that distribution was documented. "Impression: She has bilateral foot drop, left worse than right secondary to heavy metal (Pb) toxicity. Continue with AFOs bilaterally, plus Bioness Units. With patient now being just past two years from onset, this will likely be a permanent impairment."

At her deposition on May 21, 2020, Ms. Harris stated that her foot drop was most severe in June 2018 and was mildly better at present. However, she said that "nerve pain and symptoms" in her feet and legs had stayed the same. Ms. Harris also complained of "cognitive issues." When asked to elaborate, she indicated that she had "poor memory," "trouble staying on task." She said she would "just lose words and not be able to recall words that I've used 100 times." She said, "I'm currently not seeking therapies to address the specific cognition issues and I am unsure if there are any that could be offered." When asked about her mental health, she stated, "I have a lot of anxieties that I'm not able to deal with now like I was before....I have depression, mood swings, and a lot of anxieties and a lot of fears." She acknowledged experiencing bouts of intense anger or fear. She indicated that the mood issues had been "pretty steady" since the shooting. She indicated that she had been told not have children because lead in her body "would leak out and affect the child."

J. Patrick Lincoln, LCSW, LPC, LMFT issued a "Treatment Summary Report" dated July 2020 regarding nine counseling sessions he had provided to Ms. Harris. He indicated, "Presently she meets the diagnostic criteria of an adjustment disorder with anxiety and depression, moderate to severe." On June 9, 2020, Dr. Lincoln noted that she was performing well at her job: "She will be evolving in her position with more responsibilities. Received another 'win' this week from co-worker/supervisor complimenting her work to 170+ employees." Dr. Lincoln commented on more than one occasion about the presence of sleep disturbance in the patient. He indicated that she has "struggled with insomnia" (July 16, 2020), and that she sometimes would awaken from sleep up to eight times a night (August 27, 2020).

Dr. Lincoln recorded Ms. Harris' concerns regarding perceived symptoms of cognitive dysfunction. In a chart note dated May 14, 2020, Dr. Lincoln wrote, "[She] indicated she perceives her cognitive function is declining and she will forget words and memories more frequently." On July 2, 2020, he further indicated, "She is concerned she may be experiencing cognitive decline, especially memory, due to AVM (Arnold Chiari Malformation) and reaction to toxicity due lead poisoning from unremoved shrapnel. Clinician suggested she might consider a neuropsychological evaluation to determine if there is cognitive dysfunction, how serious, and ways to learn to live with successfully." He also recommended that she consider consulting a

psychiatrist who might choose to assist her further by prescribing psychiatric medication (August 20, 2020).

Sean Connolly PhD issued a "Report of Neuropsychological Evaluation" dated September 15, 2020 based on interview and testing conducted on August 13, 20, and 27. Dr. Connolly's report indicated that Ms. Harris had been entirely home-schooled by her mother, and as a child she "may have had some form of dyslexia." There were no academic achievement or intelligence tests that Dr. Connolly could use to assess her neuropsychological status and function prior to 2017. He wrote, "In terms of neurocognitive functions and brain-related behaviors, she readily acknowledges changes in her concentration, attention span, and ability to maintain focus, as well as short-term and recent memory deficits, and difficulties with word and name retrieval. She acknowledges episodes of disorientation at times.... She acknowledges some balance problems, and is unsure if this is related to the neuropathy, and has had occasional episodes of dizziness." He specifically noted that Ms. Harris, "started noticing some neurocognitive changes in the last sixth months or so" (i.e. in early 2020). He referred to her reporting a recent consultation with an unnamed "lead specialist physician", as well as a psychologist who diagnosed her with "Attention Deficit Disorder." A number of neuropsychological tests were performed. On the WAIS-IV, Ms. Harris' full scale IQ was 108, equivalent to the 70th percentile. Her general ability index score was 113, equivalent to the 81th percentile. These scores indicated that Ms. Harris' overall intelligence was superior to 70 percent and 81 percent of the population, respectively, and Dr. Connolly characterized her as having "above average intelligence." The Wisconsin Card Sorting Test (WCST) is a frequently used test of frontal lobe or high-level, "executive function" that measures the ability to exercise abstract reasoning and to exhibit mental or cognitive flexibility in solving problems. It has been included in assessment of neurotoxicity (including that attributable to lead). According to Dr. Connolly, her scores on the WCST "would support the clinical impression of the absence of any neurocognitive difficulties, associated with the frontal lobes." Dr. Connolly assessed memory using the Wechsler Memory Scale (WMS-IV) and the Complex Figure Test (CFT). Ms. Harris' percentile rank on various subscales varied between "bright normal to the average range." Dr. Connolly did not opine that Ms. Harris' neurocognitive function represented a disability or otherwise interfered with her occupational capacity. Dr. Connolly's diagnostic impression was "Mild neurocognitive disorder, due to neurotoxicity of lead in her body, without behavioral disturbance." Dr. Connolly's report did not cite any scientific literature regarding the dose-response and temporal pattern of the impact of inorganic lead on adults, nor did it comment on the potential role of nontoxicological factors (i.e. hydrocephalus, sleep disturbance, anxiety, depression) on the patient's performance.

Assessment and Opinions

1. Gunshot wounds sustained November 5, 2017 with retained extraarticular lead bullet fragments in the soft tissues of the left lower extremity, and in the soft tissues adjacent to the right shoulder and the right clavicle.
 - a. Maximum measured blood lead concentration of 8 µg/dL in June 2018; most recent blood lead concentration 2 µg/dL in October 2019.

- b. Inorganic lead released by retained bullet fragments to date has not caused any adverse signs or symptoms.
 - c. Retained lead bullet fragments are associated with an enduring future risk of the latent onset of subclinical or overt lead intoxication due to the possibility of accelerated lead dissolution. This risk merits ongoing biomonitoring and clinical awareness.
 - d. Ms. Harris' blood lead concentrations and her retained lead bullet fragments are not a contraindication to pregnancy.
- 2. Bilateral foot drop, unrelated to lead intoxication; onset February 2018, stable or slightly improved since June 2018
 - a. Arnold Chiari malformation Type I
 - b. Profound hydrosyringomyelia of the cervical spine cord documented by CT scan July 2018
 - c. Profound hydrocephalus and ventriculomegaly documented by CT scan
- 3. Elevated CSF opening pressure on lumbar puncture, July 2018
 - a. History of chronic intermittent headaches and neck pain since at least 2013
 - b. Intermittent and variable numbness and dysesthesias involving both lower extremities and the torso, onset 2016 or earlier
 - c. Impaired balance
 - d. NCV/EMG June 2018 consistent with proximal neurological lesion, but not indicative of lead-induced peripheral axonopathy
- 4. Adjustment disorder with anxiety and depression, moderate to severe, diagnosed by treating therapist J. Patrick Lincoln, LCSW, LPC, LMFT, and by Christopher Ticknor, MD
- 5. Subjective complaints of cognitive impairment, primarily in memory, first detailed in medical records in October 2019, unrelated to lead intoxication.
 - a. Neuropsychological evaluation September 2018 revealed "above average intelligence"
- 6. History of chronic disordered sleep with frequent awakenings pre-dating November 2017; no history of polysomnogram
- 7. History of concussion from martial arts incident, 2008, without loss of consciousness

The assessment of whether an adult such as Morgan Harris has developed overt signs and symptoms of lead intoxication due to systemic lead exposure from retained lead bullet fragments may be addressed by four key questions inherent in a causation evaluation: 1) Were the patient's signs and symptoms of a character known to be associated with adult lead intoxication? 2) Had the patient sustained a systemic dose of lead of sufficient magnitude to cause the signs and symptoms? 3) Was the temporal pattern between the signs and symptoms and the lead exposure consistent with a causal relationship? and 4) Were there other factors in the patient's medical history as likely or more likely to be responsible? *As detailed below, a comprehensive and systematic examination of these criteria indicates that causation from lead exposure cannot be established in Ms. Harris' case.*

1. The nature and pattern of Ms. Harris' motor and sensory signs and symptoms, i.e. foot drop and dysethesias, are not characteristic of lead neuropathy. As described in the medical records, Ms. Harris developed the progressive onset of bilateral weakness in the extensors of her distal lower extremities, termed "foot drop", beginning in January or February 2018. The condition plateaued in severity in approximately June 2018 and then slightly improved in the latter half of 2019. Ms. Harris never experienced loss of motor strength in her upper extremities. Ms. Harris complained of diminished sensation in her distal lower extremities and upper torso that was variably described on examination in mid-2018 and onward by some but not all providers. Marc Gardner PT noted that she complained of "numbness on the right side of her abdomen" in September 2018. Dr. Shriner in October 2019, and Dr. Willingham in January 2020, noted that she complained of "paresthesias along the right lateral thorax." A neurophysiological examination (NCV/EMG) conducted by Dr. Neiman on July 10, 2018 was remarkable for normal nerve conduction velocity and amplitude in the motor and sensory nerves of the distal lower extremities bilaterally coincident with her demonstrable bilateral foot drop.

The foregoing pattern of motor, sensory, and neurophysiological findings are not characteristic of lead neuropathy. First, it has long been recognized that overt lead peripheral neuropathy has a marked predilection for presenting as bilateral distal motor weakness *predominantly in the upper extremities* ("wrist drop") (Hunter, 1964; Kajiyama et al, 1993; Cory-Slechta and Schaumburg, 2000; Pickrell et al, 2013). Isolated occurrence of marked muscle weakness and atrophy in the distal lower extremities, as was exhibited by Ms. Harris, is very atypical for lead palsy. Second, lead peripheral neuropathy presents clinically as motor weakness (Windebank, 2005; Thompson and Parry, 2006). Although sensory nerves can be adversely impacted (as evidenced by electrophysiological studies), overt dysesthesia, when it does occur, is confined to areas of the body that are already markedly impacted by motor weakness or paralysis. Accordingly, the symptoms and/or examination findings in Ms. Harris of decreased or altered sensation, such as numbness or tingling involving the proximal aspects of her legs and the right side of her torso - regions without any motor involvement - are inconsistent with the toxic effects of lead.⁵

Third, the predominant pathology of lead peripheral neuropathy is axonal loss. This finding is evidenced on electrophysiological testing by decreased amplitude in peripheral nerves, accompanied in advanced cases by slowing of nerve conduction velocity (Buchthal and Bense, 1979; Ehle 1986; Wu et al, 1995). The electrophysiological testing conducted on Ms. Harris by Dr. Neiman in July 2018, which demonstrated normal amplitude of motor and sensory action potentials and normal nerve conduction velocity in the tibial, peroneal and sural nerves in the setting of severe extensor muscle weakness and overt foot drop, was inconsistent with lead-induced peripheral neuropathy.

⁵ In their review of classic lead neuropathy, Thompson and Parry (2006) noted, "This disorder is purely motor in its clinical manifestations and the distribution of the weakness is extremely unusual, *with early and severe involvement of wrist and finger extensors*, usually before any other muscle involvement....Sensory complaints are *not present*, although mild abnormalities may be found on the sensory examination, affecting all modalities." [emphasis added].

Ms. Harris intermittently reported cognitive impairment, primarily relating to memory or what Dr. Shriner characterized as “organizational skills.” Dr. Shriner noted that she reported this for the first time in October 2019, when her blood lead concentration was 2 µg/dL. This blood lead concentration was actually within the normal reference value for US adults (95th percentile value for blood lead in adults 20+ in years 2015 – 2016 = 2.89 µg/dL, CI 2.65 – 3.07; NCEH, 2019). Although overt impairment of memory and concentration can be among the nonspecific central nervous system effects of overt lead intoxication in adults, these symptoms do not occur at the low blood lead concentrations and low cumulative lead dose documented in Ms. Harris (see further below).

2. As evidenced by her blood lead concentrations that ranged from 8 µg/dL to 2 µg/dL during June 2018 to October 2019, Ms. Harris did not sustain a systemic dose of lead of sufficient magnitude to account for overt neurological signs and symptoms. Blood lead concentration is a well-established biomarker of the amount of lead circulating in the soft tissues and transported to perfused tissues and organs throughout the body. Both the extent and duration of blood lead elevation are key determinants of the magnitude of lead dose necessary for the emergence of various adverse signs and symptoms. It has long been recognized that overt symptoms of lead intoxication in adults do not emerge until blood lead concentration reaches or exceeds 30 to 40 µg/dL for a duration of days to years. At that dose or higher, some individuals may begin to experience neurocognitive symptoms such as difficulty with concentration, or a collection of additional nonspecific symptoms including headache, fatigue, sleep disturbance, anorexia, constipation, arthralgia, myalgia, and decreased libido (Kosnett et al, 2007). Hanninen et al (1979) assessed the prevalence of numerous symptoms in two groups of lead workers (n=45) with a documented record of blood lead measurements relative to unexposed control subjects (n= 23). Lead workers whose blood lead concentration had never exceeded 50 µg/dL endorsed symptoms of fatigue and depression more frequently than did the controls. Symptoms characterized as “absentmindedness” (e.g. forgetfulness and difficulty concentrating) were more prevalent than controls only among workers who had peak blood lead concentrations between 50 to 70 µg/dL. Applying a similar approach, Zimmermann-Tansella et al (1983) assessed symptoms of ill-health in three groups of adults (n=20 per group): lead battery workers with recent blood lead concentration 45 – 60 µg/dL, (group mean 52.5 ± 5.1 µg/dL); 2) lead battery workers with recent blood lead concentration below 35 µg/dL, (group mean 31.7 ± 2.9 µg/dL), and 3) non-lead exposed control subjects (male nurses), group mean blood lead concentration 20.4 ± 6 µg/dL. Members of the groups were age 30 to 45 and were matched on age, educational level and other relevant factors. On a validated symptom survey (GHQ -30) the three groups did not differ in prevalence of psychological symptoms (including concentration). Certain neurological symptoms, including “weakness in of the upper limbs”, were significantly more prevalent in the lead exposed groups, and were correlated with blood lead. Synthesizing their findings with those of Hanninen et al (1979), Zimmerman-Tansella et al concluded, “At the present state it seems therefore that lead exposure levels below 70 µg/100 ml [µg/dL] are unrelated to the number and frequency of psychological symptoms as well as to most specific psychological complaints. Some specific symptoms such as concentration difficulties and forgetfulness appear sensitive to lead exposure but only above 50 µg/100 ml [µg/dL].”

Baker et al (1984) examined the prevalence of numerous symptoms in 99 lead-exposed foundry workers (blood lead range 13 to 80 $\mu\text{g}/\text{dL}$) and 61 control workers in an assembly plant without worksite lead exposure (blood lead range 10 to 42 $\mu\text{g}/\text{dL}$). They reported, “the only symptom reported in excess was excessive tiredness, and this was only noted by individuals with blood lead concentrations above 60 $\mu\text{g}/\text{dL}$Individuals with blood lead concentrations between 40 and 60 $\mu\text{g}/\text{dL}$ did not report symptoms to a greater extent than those with lower blood lead concentrations.” In an extensive review of these and other clinical studies of lead exposed adults, the US Environmental Protection Agency concluded, “[The] lowest observed effect levels for the neurological signs and symptoms in adults can most credibly be stated to be in the 40-60 $\mu\text{g}/\text{dL}$ range” (EPA, 1986). In like manner, a review of studies of overt and subclinical neurological signs and symptoms of adult lead intoxication undertaken by the German Commission for the Determination of Occupational Exposure Limits (MAK Commission) concluded, “biological threshold values of 70 $\mu\text{g}/\text{dL}$ blood prevent manifest neurological diseases” (Schaller et al, 1987).

Subclinical adverse effects of cumulative lead exposure on cognitive function in adults have been discerned from investigations of blood and bone lead measurements and neuropsychological testing in various populations. Studies in occupational cohorts with blood lead concentrations of approximately 20 to 50 $\mu\text{g}/\text{dL}$, usually over a period of several years, have observed a correlation between blood lead and subclinical neurocognitive deficits (Kosnett et al, 2007). Krieg et al (2005) reviewed the cross-sectional relationship between blood lead and neurocognitive performance in adults enrolled in the third US National Health and Nutrition Evaluation Survey (NHANES III) and in 26 studies of adults with occupational lead exposure. The researchers concluded, “The results of the analysis of the NHANES III data do not provide evidence for impairment of neurobehavioral test performance in adults at levels below 25 $\mu\text{g}/\text{dL}$, or at lead concentrations currently found in the general adult population of the United States.” In cohorts with occupational lead exposure and a mean blood lead concentration of 41.07 $\mu\text{g}/\text{dL}$, cognitive performance was worse than controls on two tests of subclinical neurocognitive function (Krieg et al, 2005). Research has been conducted in older adults without occupational lead exposure who lived a significant proportion of their youth and adulthood at a time when background blood lead concentrations were in the range of 10 to 25 $\mu\text{g}/\text{dL}$.⁶ In these populations, bone lead concentration, a biomarker of long term cumulative lead exposure, had a stronger association than current blood lead on subclinical measures on cognitive function, including domains of memory, visuospatial ability, and executive function (Kosnett et al, 2007; Shih et al, 2007, Weuve et al, 2009). Overall, the data indicate that subclinical neurocognitive impacts of lead exposure associated with a blood lead of less than 25 $\mu\text{g}/\text{dL}$ in adults is predominantly a function of long term cumulative lead exposure acquired over many years. In this regard, it should be emphasized

⁶ Blood lead concentrations in adults in the United States from the 1940s through the 1970s were commonly in the range of 10 to 25 $\mu\text{g}/\text{dL}$ (Kosnett et al, 2007; DHHS, 1984). The National Health and Nutrition Evaluation Survey II, a large representative sample of the general population conducted from 1976 to 1980, reported a geometric mean blood lead concentration in men and women aged 18 to 74 years of 15.8 and 11.0 $\mu\text{g}/\text{dL}$, respectively (DHHS, 1984). Since the early 1980s, blood lead concentrations have declined by more than an order of magnitude owing in part to the phase out of lead in gasoline, canned food, and residential paint. In 2015 – 2016, the geometric mean blood lead concentration of men and women age 20+ years was 0.920 and 0.735 $\mu\text{g}/\text{dL}$, respectively (NCEH, 2019).

that the cumulative lead exposure sustained by Ms. Harris between November 2017 and October 2019 was very low. For example, her cumulative systemic lead dose equated to less than one year of the typical cumulative lead exposure sustained by the Baby Boomer generation born and raised in the United States between the late 1940s and the early 1970s. The entire Baby Boomer generation spent a considerable proportion of their youth and adult lives with blood lead concentrations between 10 to 25 µg/dL. Ms. Harris' most recent blood lead concentration of 2 µg/dL measured in October 2019 was in the normal reference range of the US adult population more recently (NCEH, 2019).⁷

Numerous clinical investigations and reviews have specifically examined the dose-response relationship for lead and the development of peripheral neuropathy. Neurophysiological testing conducted on adults with occupational lead exposure has determined that subtle decrements in peripheral nerve action potential amplitudes and nerve conduction velocity, consistent with axonopathy, may appear in the absence of any physical signs or symptoms of motor weakness or altered sensation (Catton et al, 1970; Vasilescu, 1973; Buchthal and Behnse, 1979; Thompson and Parry, 2006). In a review of numerous clinical studies, Araki et al (2000) concluded that the effect of lead on nerve conduction velocity "starts to occur at a mean blood lead as low as 30 to 40 µg/dL." In a meta-analysis of data from 49 clinical studies, Kreig et al (2008) determined the lowest blood lead concentration at which a dose-response for lead on peripheral nerves could be detected was 33 µg/dL for the median sensory nerve conduction velocity and 64 µg/dL for the distal motor latency of the median nerve. Overt peripheral neuropathy does not appear until even higher blood lead concentrations. Nielsen et al (1982) investigated symptoms, vibratory perception threshold and motor nerve conduction velocity in subsets of 95 lead workers (mean blood lead 51 µg/dL, range 11 -91) who worked at a lead melting factory for more than nine years, and 21 age matched control subjects (mean blood lead 10 µg/dL, range 6 -16). No subjects exhibited signs or symptoms of peripheral neuropathy on physical examination, and there were no group differences between workers and controls on motor nerve conduction velocity or vibratory perception threshold. They wrote, "The present study indicates that the neurotoxic threshold for accumulated lead had not been surpassed despite long-term lead exposure for more than 9 years. This is in keeping with the fact that clinical peripheral neuropathy has not been described in subjects with blood lead concentrations below 70-80 µg/dL" (Nielsen et al, 1982). In like manner, based on a review of the published research literature, Ehle (1986) concluded, "...clinical neuropathy is essentially nonexistent within populations with blood lead levels below 60 µg/dL." In the section devoted to lead in the chapter on metal neuropathy in the classic textbook "Peripheral Neuropathy" edited by "Dyck and Thomas", Windebank noted, "...overt neuropathy is rarely, if ever, seen in individuals with blood lead levels below 80 µg/dL" (Windebank, 2005). In a recent review of the noncancer health effects of lead, an expert panel convened by the National Research Council to assess the protectiveness of OSHA lead standards for the Department of Defense stated, "Effects of occupational lead exposure on the peripheral

⁷ The decline in Ms. Harris' blood lead concentration between June 2018 and October 2019 may have been the result of natural elimination of lead. The chelation regimen prescribed by Dr. Shriner, initially 250 mg three times a week decreasing to every other week was only a small fraction of the standard chelation regimen prescribed for individuals with elevated blood lead levels for whom chelation is indicated: 30 mg/kg-day for 5 days, followed by 20 mg/kg-d for 14 days (Ovation Pharmaceuticals, 2007).

nervous system at blood lead levels of 60 – 70 µg/dL are manifested as motor weakness with abnormalities in motor and sensory nerve conduction. No peripheral motor or sensory symptoms are known to occur at blood lead levels under 40 µg/dL, but sensory nerve function is associated with lead dose” (NRC, 2012).

As discussed above, lead neuropathy is the rare consequence of prolonged high dose exposure. Consequently, it almost always occurs together with additional multi-systemic findings of lead intoxication, such as anemia which emerges at blood lead concentrations of ≥ 40 to 70 µg/dL in adults (Kosnett et al, 2007). However, in June 2018, when Ms. Harris believed her foot drop was at its most advanced state, the complete blood count (CBC) ordered as part of panel of laboratory tests by Dr. Gazda was entirely normal, with no evidence of anemia. As noted by Windebank, “A diagnosis of clinically significant lead neuropathy in a patient without anemia should be made with great caution” (Windebank, 2005).

The blood lead concentrations measured in Ms. Harris (Table 1), ranging from 8 µg/dL in June 2018 to 2 µg/dL in October 2019, indicate that her systemic lead dose from the retained lead bullet fragments has been far below that capable of causing any overt neurological signs or symptoms. Likewise, there is no evidence that she ever sustained a blood lead concentration that has been demonstrated to cause subclinical deficits in cognitive function in adults.

3. The temporal pattern between several key features of Ms. Harris’ neurological complaints and her exposure to lead from retained bullet fragments are inconsistent with a causal relationship. Ms. Harris had prominent sensory neurological abnormalities that preceded her initial exposure to lead bullet fragments in November 2017. In May 2018, Dr. Rodriguez noted that prior to November 2017, Ms. Harris would “get numbness on the right side of the body, mostly in the right lateral leg and left shin to the point she can’t feel the razor when shaving.” In an initial neurology consultation note dated June 21, 2018, Dr. Gazda wrote, “*About two years ago she started to have right sided numbness.* She thought this was related to a pinched nerve in her neck, but it was total right sided numbness, not isolated in the arm” [emphasis added]. These sensory complaints are evidence of a pathological neurological process, unrelated to lead intoxication, that was present in Ms. Harris prior to November 2017.

During the course of multiple visits to Dr. Gazda for neurology consultation in 2018, Ms. Harris never voiced any complaints regarding impaired memory or other aspects of neurocognitive dysfunction. These complaints were first detailed in the evaluation conducted by Dr. Shriner in late October 2019, at a time when the patient’s distal lower extremity weakness was noted to have been somewhat improved. In his neuropsychological assessment, Dr. Conolly wrote that Ms. Harris’ symptoms of cognitive dysfunction first emerged as recently as early 2020. Notwithstanding that Ms. Harris’ blood lead concentrations of 8 µg/dL in June 2018 and 2 µg/dL in October 2019 were much too low to elicit any overt cognitive complaints, her blood lead concentration was higher in mid 2018 when she had no cognitive symptoms, and were not a source of complaint until a year later when the blood lead had fallen, and her distal weakness had somewhat improved. This temporal pattern is inconsistent with causation by lead.

4. Several factors in Ms. Harris' medical history unrelated to lead exposure, including Arnold Chiari Syndrome with hydrocephalus and syringomyelia, chronic sleep disturbance, and psychiatric problems may account for her neurological complaints. Ms. Harris was diagnosed with Arnold Chiari syndrome - associated with profound hydrocephalus and syringomyelia – based on a markedly abnormal head CT scan in June 2018. At the time of neurosurgical consultation on September 4, 2018, Dr. Christopher Bogaev concluded, “Ms. Harris has had worsening neurologic dysfunction from diffuse hydrocephalus as well as syringomyelia.” Arnold Chiari syndrome with hydrocephalus and syringomyelia is a rare but documented cause of distal lower extremity weakness and foot drop (Yakovlev, 1947; Saifudheen et al, 2011; McMillan et al, 2011; Panda and Kaur, 2013; Jayamanne et al, 2018). As noted by Yakolev (1947), hydrocephalic dilation of the lateral ventricles may preferentially impact nerve fibers controlling the distal lower extremities. In some cases, the reported clinical presentation may be relatively abrupt and progressive, as occurred in Ms. Harris. As noted by Panda and Kaur (2013), “Early diagnosis and treatment may halt the progression of the course with possible improvement of the disease per se.” However, Ms. Harris never had her condition treated with the placement of a ventriculoperitoneal shunt recommended as a therapeutic intervention by neurosurgeon Dr. Bogaev.

Hydrocephalus that is present in Ms. Harris is also a recognized cause of headaches and cognitive dysfunction (Botez et al, 1977; Del Bigio et al, 2003; Iddon et al, 2004; Newman and Segal, 2004; Novegno et al, 2008; Cheng et al, 2013; Smith and Buckley, 2012; Hayhow et al, 2014). Cognitive dysfunction, which may be overt or subclinical, has been particularly noted to involve memory and executive function, and in some cases may be delayed and progressive.

Ms. Harris reported a history of frequent nocturnal awakening and disordered sleep that predated the November 2017 gunshot wounds. Dr. Rodriguez, who noted that Ms. Harris would often awake fatigued, listed “daytime sleepiness” among the patient’s diagnoses. Dr. Lincoln wrote that Ms. Harris struggled with insomnia, and at times would awaken up to eight times per night. Disordered sleep may be a significant etiological factor for Ms. Harris’ complaints of cognitive dysfunction and fatigue (Fulda and Schultz, 2010; Cipolli et al, 2013).

Dr. Lincoln in 2020 diagnosed Ms. Harris as having an adjustment disorder with anxiety and depression, moderate to severe. Dr. Tricknor diagnosed the presence of an adjustment disorder with depressed mood symptoms in late 2019. Although Dr. Lincoln suggested a psychiatrist might improve her condition by prescribing medication, there was no indication in the records available for review that Ms. Harris was ever treated with antidepressant or anti-anxiety medication. Ms. Harris’ depressed mood may be a significant factor in her symptoms of impaired memory and complaints of cognitive dysfunction (Austin et al, 2001; McDermott and Ebmeier, 2009).

In view of all of the foregoing, in my opinion, lead exposure from retained lead bullets has not been a causal factor in any adverse signs or symptoms experienced by Ms. Harris.

The retained lead bullet fragments in Ms. Harris pose an enduring future risk of the latent onset of subclinical or overt lead intoxication due to the possibility of accelerated lead dissolution. This merits ongoing periodic biomonitoring for blood lead, and clinical awareness on behalf of the patient and her health care providers. Although the magnitude of the risk of overt lead intoxication in the future cannot be precisely estimated, available data indicate that it is low and such an occurrence is not probable. On the order of 100,000 non-fatal firearm injuries occur in the United States each year. In many of these injuries, retained lead bullet fragments not located within a joint space, the palm or sole, or compressing a major neurovascular structure are not surgically removed in order to limit the risk of surgical intervention and to allow the fragment to be encased in fibrous scar tissue and remain nearly inert (Nickel et al, 2018). Most states collaborate with the Adult Blood Lead Epidemiology and Surveillance (ABLES) program operated by the CDC's National Institute for Occupational Safety and Health in reporting the number and source of elevated blood lead concentrations measured by clinical laboratories. During 2003 – 2012, a total of 41 state ABLES programs reported 145,811 adults with blood lead concentrations > 10 µg/dL from all causes, including 457 (0.3%) cases in individuals with retained bullet fragments (Weiss et al, 2017). As a percentage of individuals surviving gunshot wounds, or as a percentage of individuals with blood lead concentration > 10 µg/dL, the contribution of those with retained lead bullet fragments is low.

Apte et al (2019) recently conducted a systematic review and meta-analysis of the literature to assess the association between retained lead bullet fragments and elevated blood lead levels in survivors of firearm injury 16 years and older. In a meta-analysis of a pooled sample size of 462 subjects derived from acceptable studies, the mean blood lead concentration of individuals with retained bullet fragments was higher than that of control subjects by 5.47 µg/dL (95% C.I. 3.70, 7.24). McQuirter et al (2004) conducted a prospective study of 451 subjects with a first-time gunshot injury and retained bullet fragment in Los Angeles between 2000 to 2002. Multiple blood lead measurements were made at baseline and up to 24 months following the injury. The study found on average that blood lead peaked within the first year and then trended downward. At 3 months post injury, 38.1 % of blood lead levels were greater than 10 µg/dL, declining to 20.1 percent at 12 months. The presence of a bone fracture in the torso, or of a bullet lodged near a bone or a joint, increased the risk of an elevated blood lead level. Nguyen et al (2005) at Cook County Hospital in Chicago assessed blood lead concentration and possible symptoms of lead toxicity in 120 adults with a past history of extra-articular retained bullet fragments and 120 age and gender matched controls. The mean blood lead concentration was 6.71 µg/dL (95% CI 5.68 – 7.74 µg/dL; range: < limit of detection to 33.1) in the subjects with retained bullet fragments, and 3.61 µg/dL (95% CI 2.79 – 3.53 µg/dL) in control patients (P = 0.0001). There was no significant difference in the number of symptoms associated with lead toxicity between the two groups, nor was there a correlation between the number of symptoms and blood lead level.⁸ The mean time of bullet fragment retention was 4.60 years (range 1 day to 51 years). Longer duration of fragment retention was not associated with higher blood lead concentration. Ninety-six

⁸ Nguyen et al (2005) commented, "It is also likely that none of the whole blood lead levels in our study were high enough to cause noticeable symptoms."

percent of the subjects with retained bullet fragments had a blood lead concentration less than 20 µg/dL.

It may be seen that Ms. Harris' experience, a peak blood lead concentration of 8 µg/dL occurring less than one year after her gunshot injury that subsequently declined to 2 µg/dL, has been relatively consistent with the pattern described in large prospective studies of individuals with retained lead bullet fragments. Nonetheless, there is a low risk that in some patients such as Ms. Harris, a retained lead bullet fragment may migrate to a joint space or a fluid filled cyst that hastens dissolution of the lead in the fragment and results in severe lead intoxication that requires medical treatment (Dillman et al, 1979; Linden et al, 1982). This has sometimes occurred years to decades after the initial gunshot injury. Accordingly, it is recommended that Ms. Harris undergo annual blood lead surveillance to assess the trend in her blood lead concentration (McQuirter et al, 2004; Nickel et al, 2018). This surveillance should be conducted more frequently, as indicated, if she manifested overt signs and symptoms potentially associated with lead toxicity, such as severe headaches, weight loss, persistent abdominal pain, anemia, or altered mental status. Ms. Harris, her family, and her health care providers should be educated to be alert to the potential role of lead toxicity in otherwise unexplained signs and symptoms that might emerge in the future. Depending on the severity of the signs and symptoms and the magnitude of the elevation of blood lead concentration, therapeutic interventions such as surgical or endoscopic removal of a bullet fragment from a joint space or cystic space, or chelation, may be indicated. Patients with blood lead concentrations of 80 to 99 µg/dL, with or without symptoms of lead toxicity, and some symptomatic individuals with blood lead concentrations of 50 to 79 µg/dL, may be considered for chelation treatment (Kosnett et al, 2007; Gaitens et al, 2020). Chelation of adults with lower blood lead concentrations is usually not indicated. The therapeutic efficacy of lead chelation in mitigating or reversing adverse health effects in patients with low blood lead concentrations is not established (Kosnett, 2010). The latent onset of severe lead intoxication requiring surgical or chelation intervention in patients with retained lead bullet fragments is rare. Ultimately, management decisions should be made in consultation with experienced specialists in surgery, medical toxicology, or occupational medicine.

Comments on opinions of plaintiff experts L. Douglas Wilkerson, MD and Christopher Ticknor, MD. For numerous reasons, I respectfully disagree with opinions and conclusions contained in the March 30, 2020 medicolegal report issued by plaintiff expert L. Douglas Wilkerson, MD. In his report, Dr. Wilkerson attributed Ms. Harris' foot drop to a lead-induced "subacute progressive distal neuropathy," and her cognitive symptoms to "mild chronic lead encephalopathy." In so doing, the report entirely omitted any scientific discussion of the extensively studied relationship between blood lead concentration, lead dose, and lead-induced peripheral neuropathy and cognitive symptoms and performance in adults. Remarkably, Dr. Wilkerson's report on lead intoxication failed to state any of the blood lead concentrations measured in Ms. Harris and omitted any citation to scientific literature on the topic. The report presented no foundation based on scientific and medical research for the assertion that the low level of systemic lead exposure documented by Ms. Harris' blood lead concentrations could have caused her

neurological signs and symptoms. His report did not describe how the electrophysiological (NCV/EMG) and clinical neurological findings in Ms. Harris differ with those reported in the medical literature to occur in actual cases of lead-induced peripheral neuropathy. With regard to temporality, Dr. Wilkerson's report incorrectly stated that Ms. Harris had "no prior neurologic symptomatology," an assertion at odds with the numerous accounts in her medical records of neurological symptoms that pre-dated November 2017. Without requesting, performing, or reviewing a formal neuropsychological assessment, Dr. Wilkerson's report characterized Ms. Harris as having a cognitive profile "typical of an individual with special needs who would require accommodation in the workplace for a worker of *lower than average cognitive ability*" (emphasis added). This conclusion was counter to comments in the medical record documenting Ms. Harris' positive work performance, and the findings by Dr. Connolly's neuropsychological assessment that Ms. Harris actually demonstrated "above-average intelligence." This neurology report by Dr. Wilkerson failed to discuss, based on data in the medical literature, how neurological risk factors unrelated to lead exposure, notably Arnold-Chiari syndrome with hydrocephalus and syringomyelia and chronic sleep disturbance, could account for Ms. Harris's symptoms and findings. In my opinion, Dr. Wilkerson's approach to causation assessment – an approach without foundation in the scientific literature and data that detailed the nature and dose-response aspects of the adverse effects of lead and without adequate consideration of the contribution of alternative factors -- was contrary to standard and reliable principles and methodology in medicine and clinical toxicology.

I also consider the unequivocal admonition made by Dr. Wilkerson and other healthcare providers that Ms. Harris should avoid having children because of retained lead fragments to be scientifically unwarranted and unjustified. Without discussion of Ms. Harris' cumulative lead dose or blood lead concentration or citation of any scientific literature, Dr. Wilkerson wrote in his expert report, "Based on current knowledge, therefore, the retained lead in shrapnel and the lead sequestered in bone from prior plasma flux pose dire risk for fetal brain damage from lead and thus advice is given to Ms. Harris-Workman she that avoid pregnancy." In like manner, without any reference to Ms. Harris' blood lead concentration or the scientific literature, Christopher Ticknor, MD, wrote in his medicolegal report, "For a 22-year-old woman like Morgan Workman, this means that if she were to conceive a child, exposure to lead toxicity in utero would ultimately lead to brain damage and permanent disability in the child." According to available records, Ms. Harris' most recent blood lead concentration of 2 µg/dL measured on July 29, 2021 is within the normal reference range of adult women in the United States today (NCEH, 2019). *There is no scientific evidence that becoming pregnant with this normal blood lead concentration poses an increased risk of giving birth to a child with brain damage or permanent disability* (Ettinger and Wengrovitz, 2010). Dr. Wilkerson infers, without scientific foundation, that since she was shot on November 5, 2017 Ms. Harris has accumulated a high level of lead in bone that would be remobilized during pregnancy, resulting in a high blood lead concentration that would cross the placenta and pose a risk for fetal brain damage. In fact, the increment in blood lead experienced by Ms. Harris in the 3 ½ years since she was shot, when her blood lead ranged from 8 µg/dL to 2 µg/dL, would have been associated with only a slight increase in bone lead compared

to a typical woman of her age, likely less than 1 ppm.⁹ By comparison, virtually all people alive today who were born before 1980, when typical blood lead concentrations in the general population ranged from 10 to 25 µg/dL, were born to mothers who likely had a much higher blood lead concentration, a higher cumulative blood lead index, and higher bone lead concentration than would be the case for Ms. Harris were she to become pregnant with a blood lead of 2 µg/dL. Pregnancy is not associated with accelerated dissolution of retained lead bullets. Although there is a low risk that Ms. Harris could coincidentally experience a marked increase in blood lead from migration and/or accelerated dissolution of a retained lead bullet fragment during 9 months of pregnancy, it is far more probable that this would not occur, and she would give birth to a normal healthy child.

My opinions in this report are stated to a reasonable degree of medical probability and are based on my review of the medical and case records and pertinent literature, along with my medical and toxicology education, training and experience.

Respectfully submitted,



Michael J. Kosnett, MD, MPH, FACMT

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⁹ A person's bone lead concentration is correlated with their cumulative pattern of blood lead concentration, which in turn is a reflection of their cumulative lead dose (Hu et al, 2007). This has sometimes been referred to as cumulative blood lead index, expressed in units of µg/dL • years. The ratio of bone lead concentration to cumulative blood lead index is approximately 0.05. In the 3.5 years since she was shot in November 2017, Ms. Harris' blood lead concentration has ranged from 8 µg/dL in 2018 to 2 µg/dL in 2019. Assuming she continued to maintain a blood lead of 2 µg/dL to the present time, her cumulative blood index since being shot could be roughly estimated to be about 13 µg/dL•years, which would be associated with a bone lead increment of $13 \times 0.05 = 0.65$ ppm. A typical woman who had a blood lead concentration of 1 µg/dL over the past 3.5 years would have had an associated increment in bone lead of 0.175 ppm ($\approx 3.5 \times 0.05$). This difference in maternal bone lead, approximately 0.5 ppm, would not result in an appreciable increase in fetal lead exposure, particularly in a well-nourished pregnant woman with sufficient calcium in her diet (Ettinger et al, 2009).

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Appendix: Medical Records and Case Documents Reviewed

Medical Records and Reports

Connally Memorial Medical Center

Sean G. Connolly, PhD, report of neuropsychological evaluation dated 09/15/2020

Manuel T. Davis, Jr. Ecumenical Center for Education, Counsel and Health

Emergency Clinic at La Vernia

Marc Gardner, PT, Crossover Magenta Health Clinic

Suzanne K. Gazda, MD, Neurology Institute of San Antonio

J. Patrick Lincoln, Jr., LCSW, LPC, LMFT

Neurosurgical Associates of San Antonio, Arnold Vardiman, MD, and Christopher Bogaev, MD

Irmo Marini, PhD, Vocational analysis 03/30/2020

Joseph C. Michael, DC Life Essentials Chiropractic & Wellness Centers

Sandra Shriner, MD, Aidia Individualized Care

South Texas Radiology Imaging Centers

Michelle Rodriguez, MD, Crossover Magenta Health Clinic

Christopher B. Ticknor MD, report dated 12/19/2020

University Hospital (San Antonio)/University Health System

L. Douglas Wilkerson, MD, report dated 03/30/2020

Alex Willingham, MD, New Patient Evaluation from dated 01/16/2020

Case documents and other materials

Deposition of Morgan Harris 05/21/2020

Melissa Chan, The poison in their blood. Time 07/08/2019